Status of Source Specific Station Correction (SSSCs) for IMS Seismic Stations in North Africa, Middle East, Mediterranean and Western Eurasia (Group2 region)

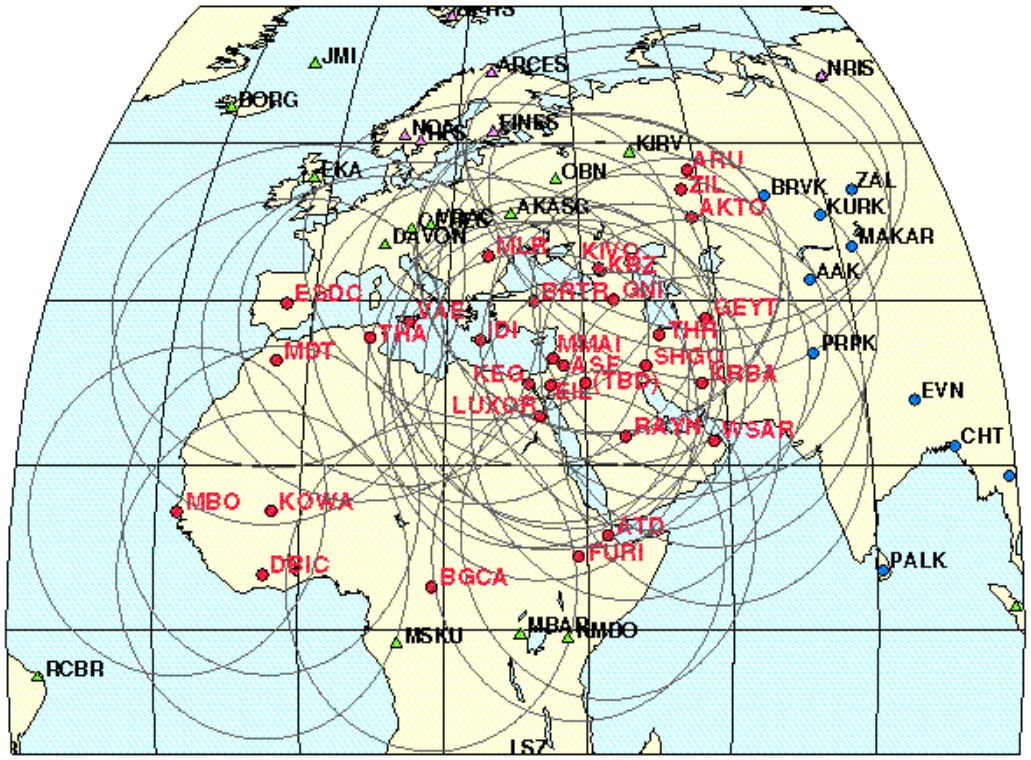
Group2 Consortium

Oslo Workshop

April 24, 2001

http://g2calibration.cmr.gov/calibration/Presentations/Oslo/Oslo-2001-sssc.pdf

Overview



- Objectives
- Group2 Participants
- 3D model development
- SSSC computations
- Future Plans

Project Objectives

Improve locations based on the sparse IMS network, reduce location bias and uncertainties

Calculate regional travel times for selected stations in the region by ray-tracing through a 3D model

- Develop 3D models (global/regional body/surface wave tomography, regionalized models)
- Represent predicted travel times as correction surfaces centered on stations relative to IASPEI91
- Develop model errors for the travel times
- Validate models and corrections using reference events (demonstrate that locations improve)

Consortium: 2-phase, 3-year project

- Project started in April, 2000
- Task: deliver correction surfaces for IMS stations in the region
- First delivery, June 2001:
  - models based on existing data and models, preliminary correction surfaces for surface sources (at 10 km depth), reference event list
- Final delivery, January 2003:
  - Final models, refined, depth-dependent correction surfaces, reference event list
- Web site: http://g2calibration.cmr.gov

Project Participants

SAIC - Coordination, regionalization, reference event collection, software integration, testing, validation

University of Colorado, Boulder – Model development, travel time computation, reference event collection

Harvard University – Model development, SSSC computation, reference event collection

University of California San Diego – Model development, model validation

Multimax - Reference event collection and analysis

Geophysical Institute of Israel – Reference event collection and analysis

Project Methodology

- 3-D Model Construction
- Model Validation
- Raytracer Development
- SSSC computation
  - 1000 stations, 2 models, 4 phases
- Error Estimation

GT Information

Cluster Analysis

Engdahl et al., this workshop

Validation Tests

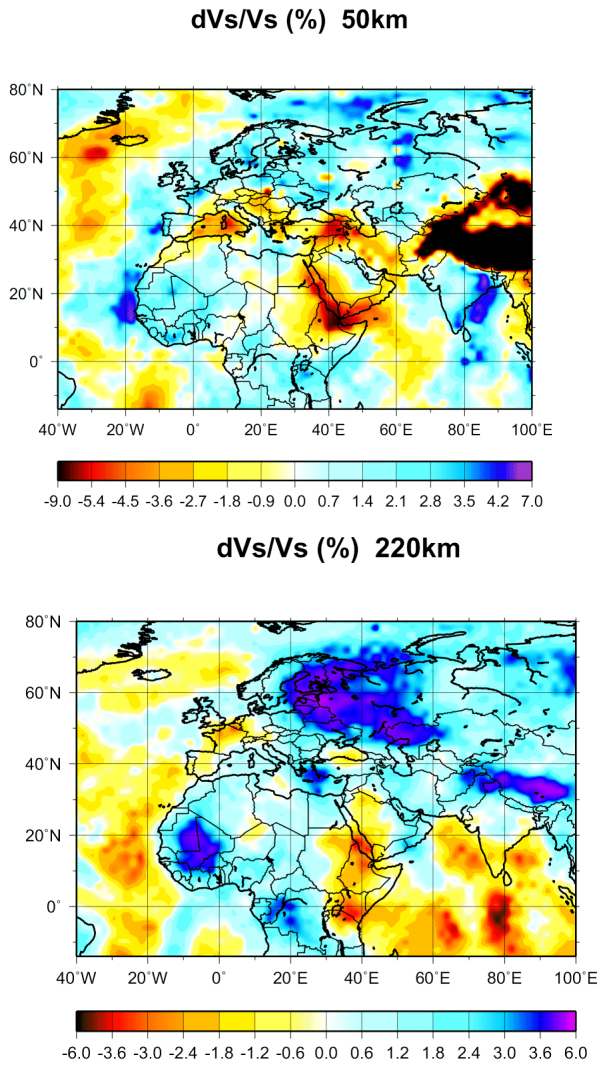
Event Relocations

Group2 Consortium, this workshop

Project Status

- Model Construction
  - Developed Colorado 3-D Crust + Upper Mantle Model
  - Developed Harvard 3-D Whole Mantle Model
  - Developed SAIC Regionalized Crustal Model
  - Utilizing Scripps High-Resolution Sediment Model
- Model Validation
  - Model validation Tests have started at Scripps
- Raytracer Development
  - Developed two separate methodologies
  - Being installed and computed at SAIC
- SSSC Computation and Event Relocation
  - Ongoing at SAIC and CU, Boulder
- Error Estimation
  - Preliminary Methodologies developed
  - Working group created

CUB1.0 Model (Crust + Mantle, Vp and Vs)



Datasets Used

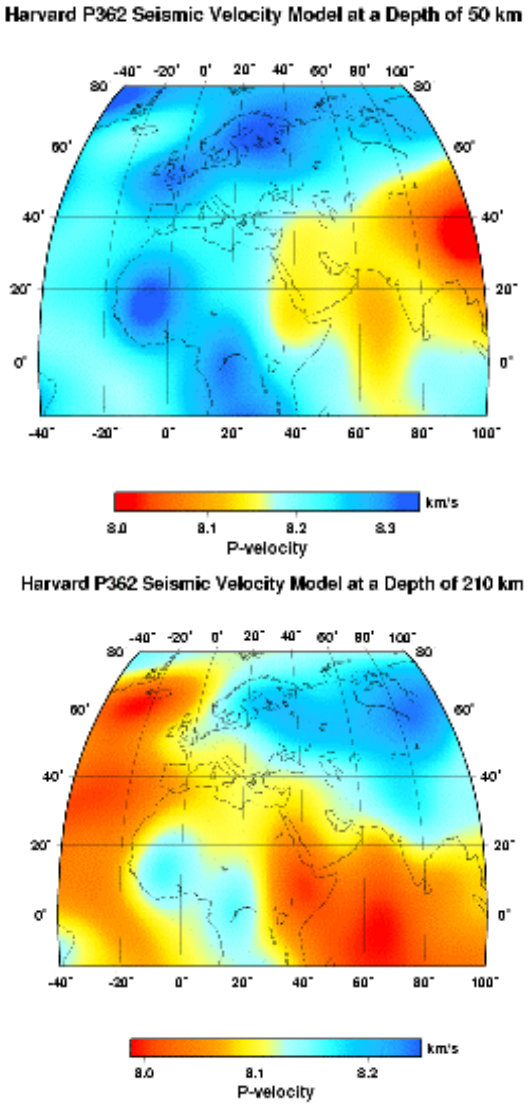
- **Group Velocities: CUB + LLNL**
  16 - 200 s (70,000 paths)
- **Phase Velocities: Harvard + Utrecht**
  40 - 150 s (50,000 paths)
- **Travel Time: Pn from EHB**
  1,000,000 arrivals
- **Constraints: *Apriori* Models**
  Crust5.1
  UCSD sediment model

Lateral Resolution: 400 km

Vertical Resolution:
Crust: 5 km
Mantle: 100 km

Ritzwoller et al., this workshop

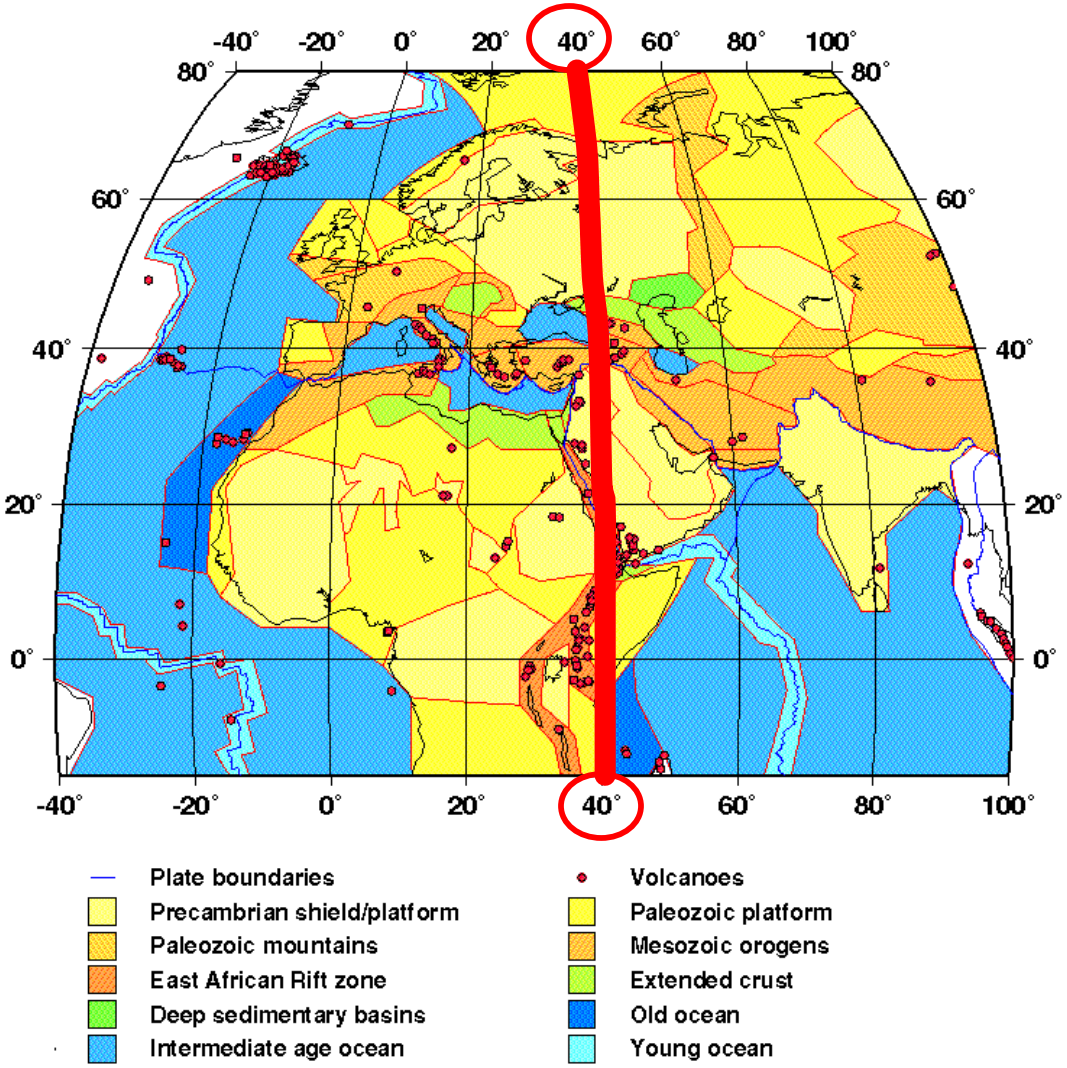
Harvard Model (Mantle, Vp and Vs)

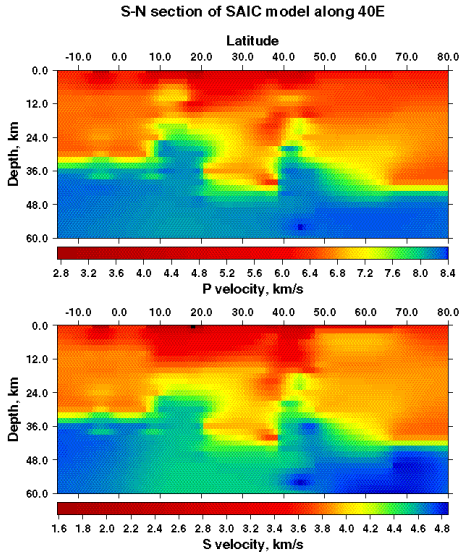


- Dataset Used
  - Relocation of sources in a prior 3-D model
  - Teleseismic summary rays (P & S) (6,26,000 rays)
  - Crustal correction (CRUST5.1)
  - Surface wave dispersion (60,000 Love and Rayleigh **phase velocities** between 35 – 150 s)
- Modeling
  - Parameterization: 25 km – CMB
  - Joint inversion of P and S models
  - Large scale structures
  - Antolik et al., this workshop

Oslo Workshop, 2001

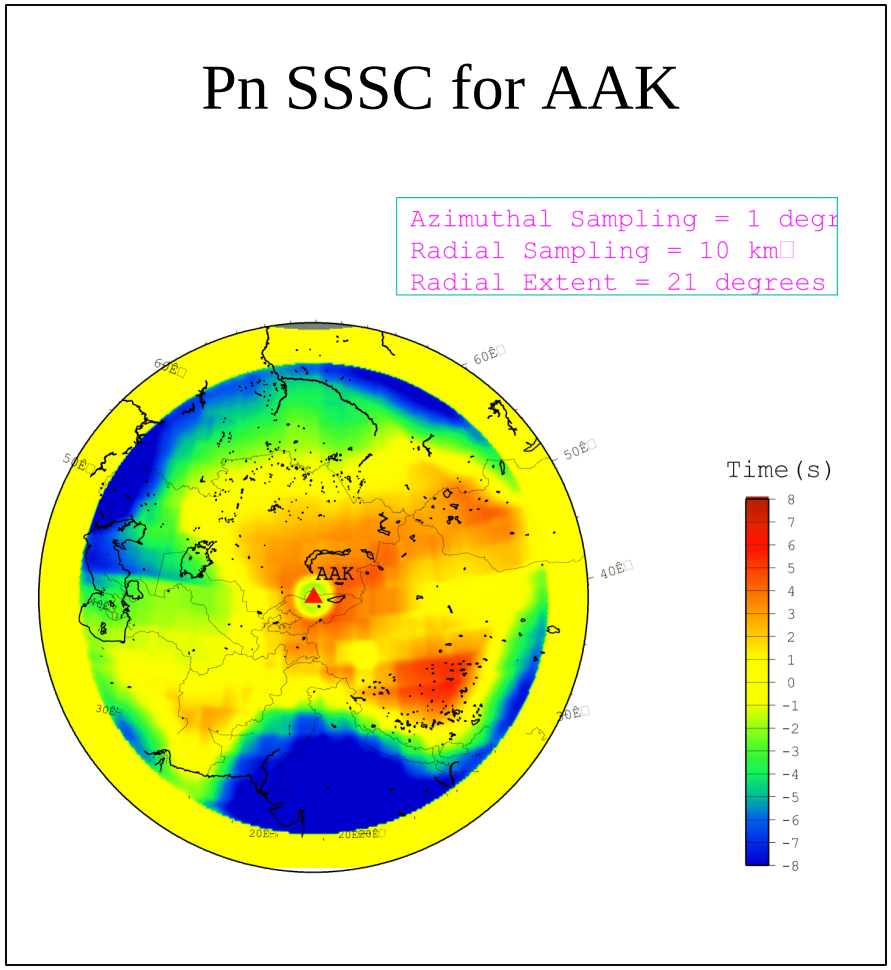
SAIC Model (Crust Vp, Vs)





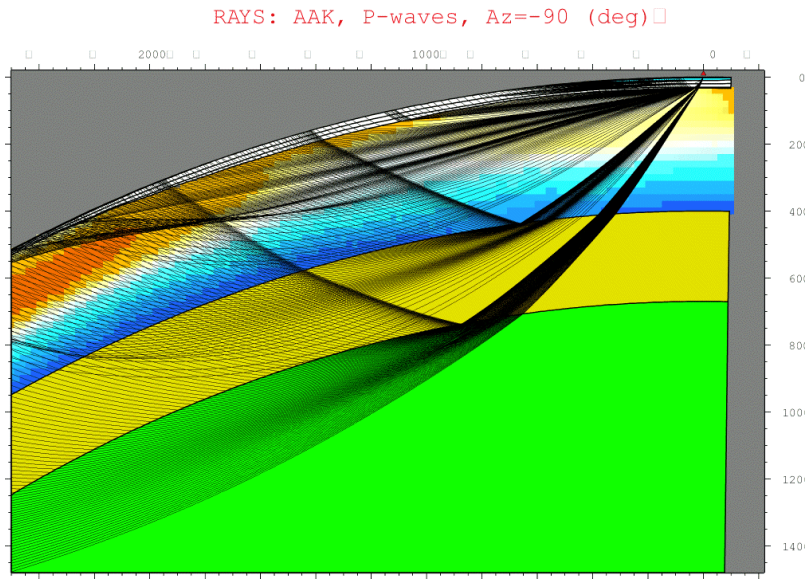
- Based on seismic regionalization using:
  - –Tectonic maps
  - –Published literature
  - –Existing regionalizations
- Each region has a 1D velocity model (P, S)
- Merged with Harvard models
- http://g2calibration.cmr.gov/calibration/Models/SAIC (version 1.0)

3-D Raytracing



- Finite Difference Calculations
  - Finite Difference travel time calculator of Podvin and Lecomte (1991) and implemented by Villasenor et al. (2000)
  - Allows different propagation modes (diffraction, head, etc)
  - Computed for a 2 km X 2 km grid
- Limitations
  - Slow and difficult to compute later arrivals

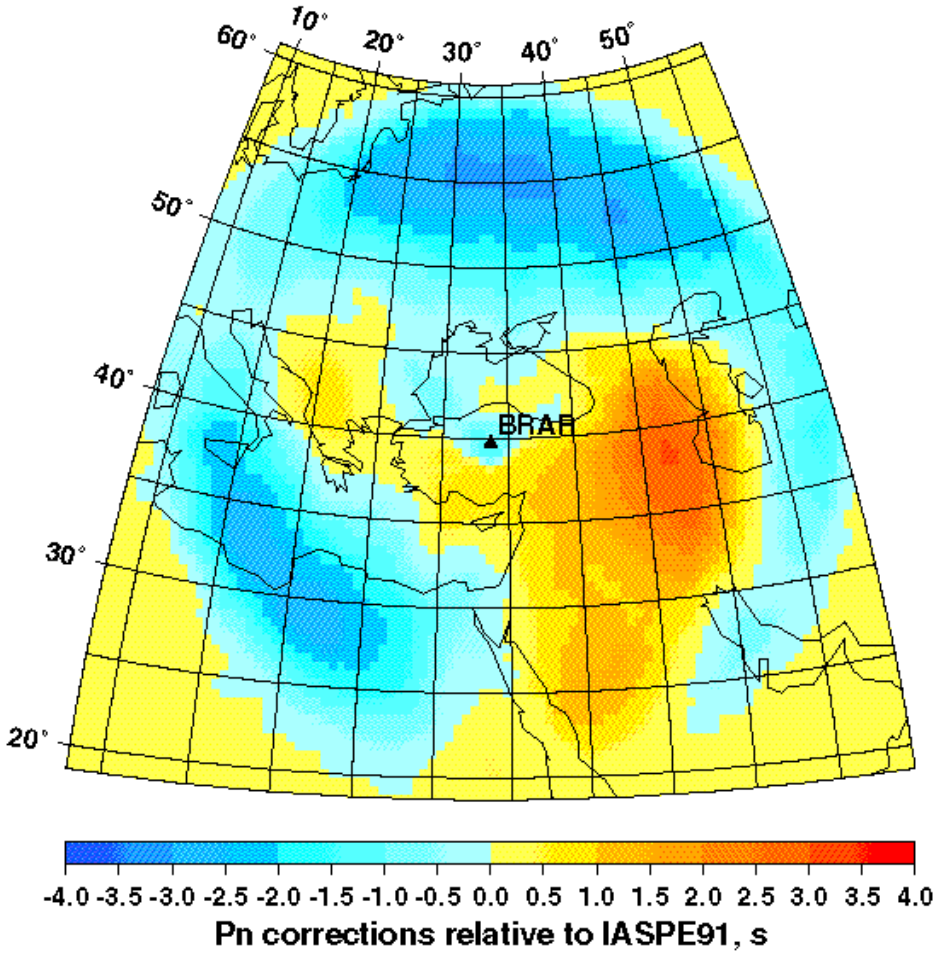
3-D Raytracing (Contd.)



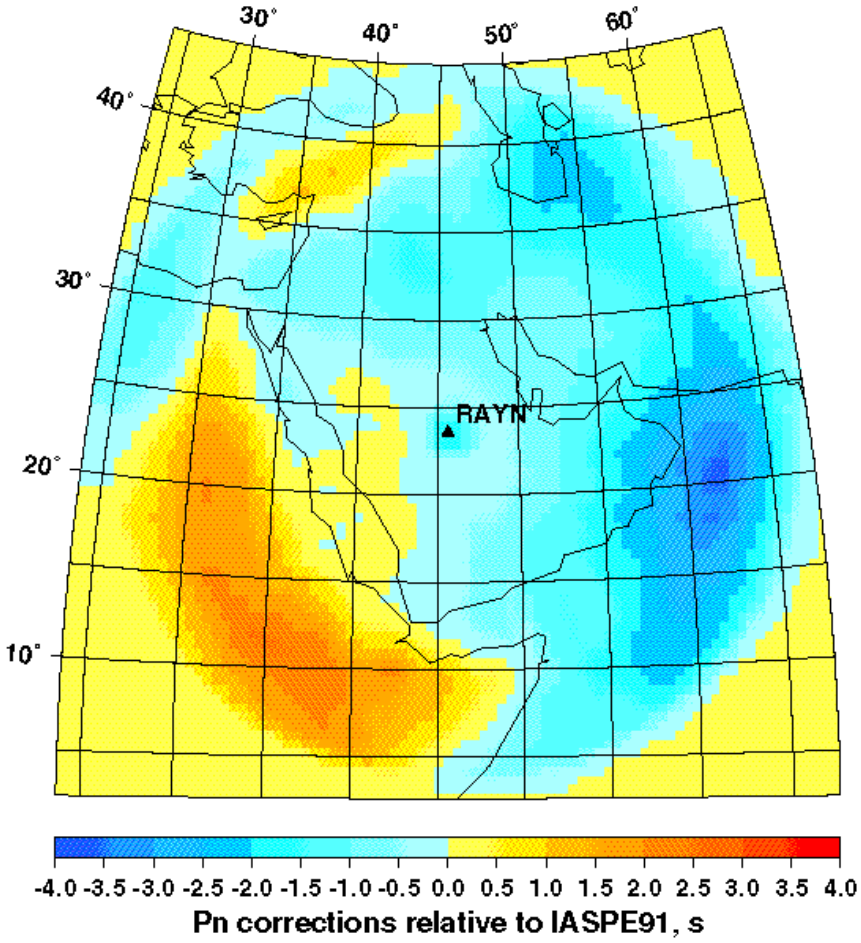
- D2TRACERDN Code
  - Phase specific
  - Developed by CU, Boulder
  - Calculation of refracted P or S travel times in 3D laterally inhomogeneous media with curved interfaces by the ray method.
  - Program constructs P or S 3D travel time table (TTT) within 20 degree from an arbitrary station for the sources at depths 10, 20, 30, 40, 50 km
  - D2tracerdn is based on the well known Psencik-Cerveny ray method for 2D layered structures.
  - Time: 20 mins / SSSC

Correction surfaces

Belbasi array, Turkey



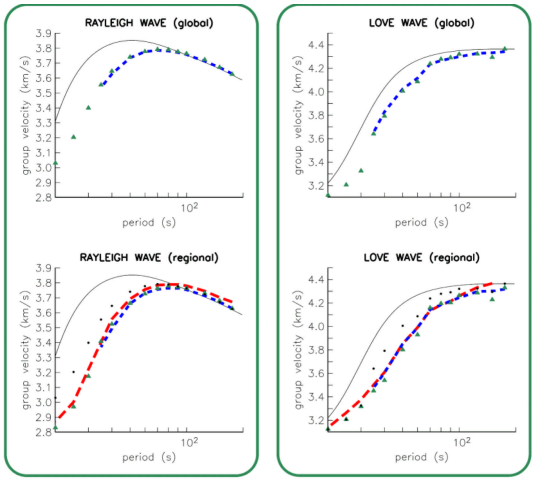
Ar Rayn, Saudi Arabia



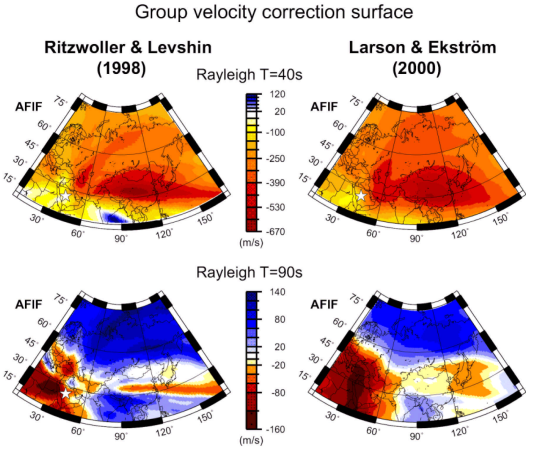
Oslo Workshop, 2001

Model Validation

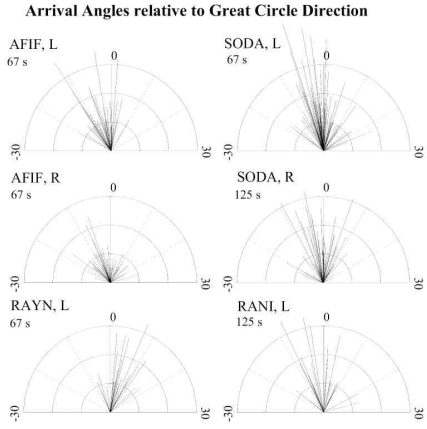
- **Model validation tests using independent surface wave datasets have begun at Scripps**
- **The following parameters are being evaluated:**
  - **Dispersion curves: phase velocity (Harvard) and group velocity (Colorado)**
  - **Surface wave maps: model based predictions**
  - **Surface wave arrival angles / polarization data**



Comparison between measured and predicted path averaged group velocities for the Saudi array. Green triangles represent measurements and the predictions are for PREM (black), Harvard (blue) and Colorado (Red).



Group velocity correction surfaces wrt anisotropic PREM, plotted at the source location. Models differ significantly.



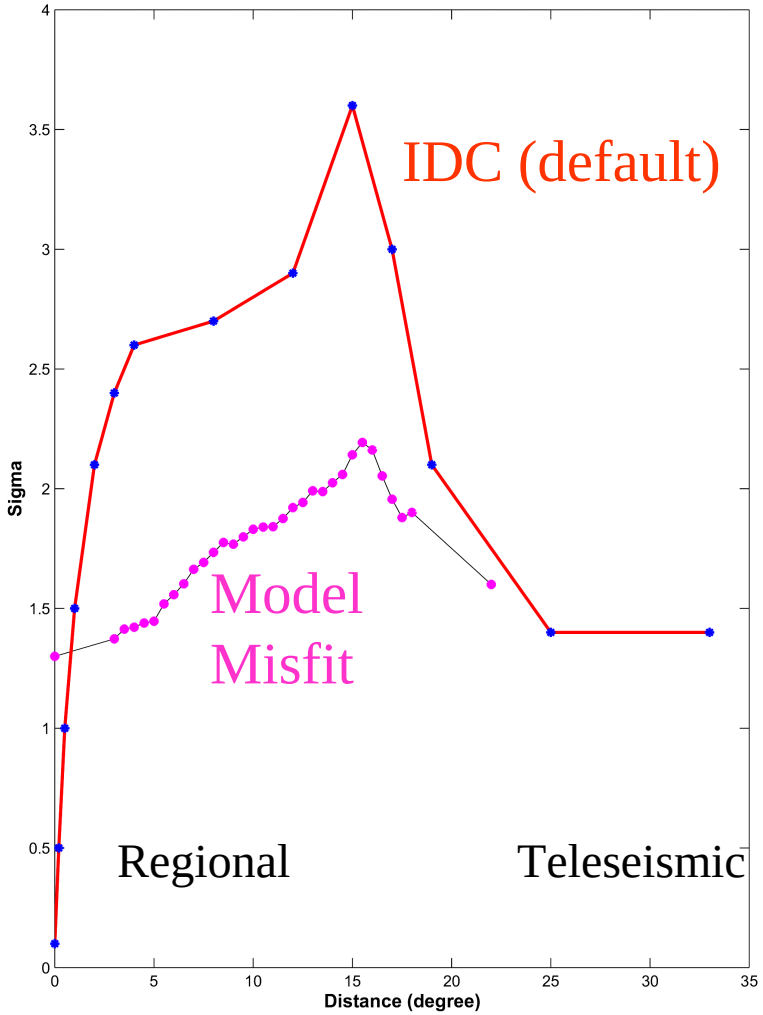
Polarization data highlighting off-great-circle-path arrival and Station misalignment (67 – 125 s).

Model Error Estimation Methodologies

1. Model based: Analyzing the variability between SSSC surfaces computed for the two (HRV and CU) models.
2. Data based: Compute 1-D variogram (epicentral distance vs. TT residual) for all of the stations in the region, including non-IMS stations to get good spatial coverage, using a travel time data set and the 3-D model with which the SSSC's are being generated.
3. Using corrections derived from HDC/JED analysis of event clusters (Engdahl et al., this workshop).
4. Ad hoc error bounds based on our knowledge of how well we know the structure in a region. To be vetted by 3-D modelers.
5. The default IDC values, maybe in regions of sparse data and/or model coverage.
6. Develop a methodology for handling error surfaces where we have reference events.
7. Limited Monte Carlo tests with the models, only if necessary.

Model Misfit Based Error Estimation

- Based on model based travel-time residuals, we construct region-wide azimuthally independent error surfaces for the SSSCs (Ritzwoller et al., this workshop)
- Station specific error estimates will be developed



Conclusions

- 3-D Models:
  - Developed and installed two separate global seismic models
  - Developed a regionalized crustal model
- Travel Times:
  - Computed phase dependent SSSCs for regional P and S phases at 10 km depth
- Modeling Errors:
  - SSSC error methodology developed and applied
- Model Validation:
  - Model validation is ongoing
- Event Relocation:
  - Started; discussed in the next presentation

Future Work

Schedule Till June, 2001:

Finalize Phase 1 SSSCs (SAIC, CUB)

Carry out model validation tests and event relocations (SAIC, Scripps)

Finalize model errors (SAIC, CUB, Harvard)

Starting Phase 2

- Identify problems and refine the models
- Improve 3-D raytracer
- Develop improved SSSC error estimates
- Validate models